CHAPTER 4

COMBAT SYSTEMS

Compared with older combatant ships, today's combatants have more, and increasingly complex, electronics and weapons equipment and systems. Therefore, changes must be made to the traditional organization of divisional responsibilities. This means combining some of the responsibilities of the operations and weapons departments. Current practice calls for putting one officer, the combat systems officer, in charge of all weapon system (all weapons and electronics subsystems) maintenance. This combines (integrates) the maintenance of all electronics and makes the ship more capable of fulfilling its mission. In some configurations, it is possible that the engineering department will supply personnel for supporting systems, such as gyro distribution, cooling systems, and primary and secondary power.

All subsystems of a combat system–weapons, search radar, communications, ASW, electronic warfare and sonar–interface through the NTDS/CDS subsystems. These collectively compose a "single shipboard system." Figure 4-1 illustrates typical external components of a combat system.

In the past, technicians were only concerned with maintaining their assigned equipment so it operated when it was needed. Under the combat systems concept, technicians must also ensure the accuracy of their equipment's and systems' outputs into the combat system. This means that technicians must cross traditional boundaries and become familiar with the operation and capabilities of the overall system. The outputs of combat system equipment into the combat direction system (CDS) and weapon system control equipment must be accurate, or within assigned standards. Without accurate signals and data, the ship may not be able to handle its combat mission.

SUBSYSTEMS

Many different subsystems are used aboard the various U.S. Navy ships. We will use the subsystems aboard some of the FFG-7 class ships as examples. Our description is basic (without security compromise), but it will give you a general idea of how the subsystems operate and how they are integrated with the rest of the combat system.

SEARCH RADAR SUBSYSTEM

The search radar subsystem provides primary surveillance, detection, and tracking data for antiair warfare and anti surface ship warfare missions. The following paragraphs functionally describe the combat system radars, radar recognition, and search radar repeaters. Search radars include Radar Set AN/SPS-49(V)4 and Radar Set AN/SPS-55. Radar identification includes the Air Traffic Control Radar Beacon System/Identification Friend or Foe (IFF) Mk XII System (AIMS). The search radar repeaters consist of three AN/SPA-25 indicators.

Search radar subsystem target information used to detect air and surface targets is provided by two-dimensional search scans. This information is sent by the appropriate radar distribution switchboard to user consoles as video and sweep data. The interrogation sets, as part of the radar recognition equipment, send IFF data via the radar distribution equipment to the video decoders and the beacon video processor.

COMBAT DIRECTION SUBSYSTEM (CDS)

The combat direction system (CDS) subsystem is a digital computer-based data processing system that allows the crew to integrate, control, monitor, and make tactical use of the ship's weapons systems. It also allows the use of task force weapons against air, surface, and subsurface threats. Sensor data from radar, sonar, countermeasures, and remote communication links are collected, correlated, and evaluated by the CDS operational program. The CDS program then develops and sends recommendations and alerts to the console operators to enable them to use their sensor and weapon resources efficiently. The CDS is composed of the following major equipment groups:

1. CDS data processing group
2. CDS data display group
3. CDS data communications group

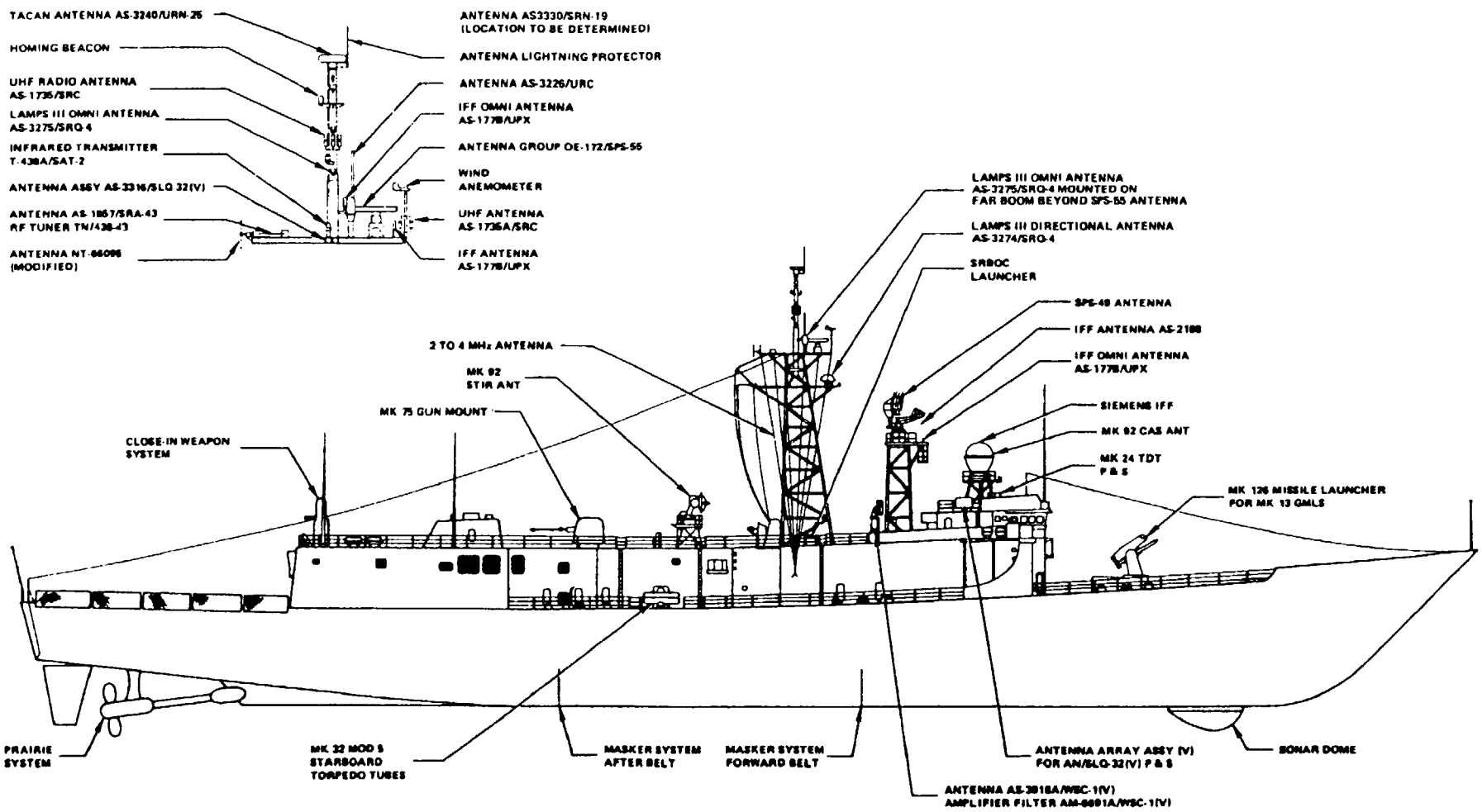


Figure 4-1.–Typical external components of a combat system (FFG-7 Class).

Figure 4-2 is a pictorial diagram of how the search radar subsystem interfaces with the combat direction system subsystem.

COUNTERMEASURES SYSTEMS

The countermeasures subsystem, a stand-alone subsystem, provides the combat system with detection, surveillance, identification, and engagement capabilities against threats the ship encounters during a mission.

The countermeasures subsystem is divided into three functional groups: the electronic support measures (ESM) group, the acoustical countermeasures group (ACM), and the electronic countermeasures (ECM) group.

The ESM group supports actions taken to search for, intercept, locate, record, and analyze radiated electromagnetic energy in support of tactical operations. Thus, ESM equipment provides a source of countermeasures information required for threat detection, warning, avoidance, and target acquisition. The ESM group also receives triggers from shipboard emitters, and develops the blanking pulses required to prevent the emitters from interfering with operating countermeasures equipment. The major components of the ESM group are the Electronic Countermeasures Set AN/SLQ-32(V)2 and the Blanker-Video Mixer AN/SLA-10B.

The ACM group provides deception devices designed to provide a false or misleading acoustical target for incoming acoustical homing torpedoes. The major components of the ACM group arc the Torpedo Countermeasures Transmitting Set AN/SLQ-25 (NIXIE) and the PRAIRIE/MASKER SYSTEM.

The ECM group provides false or misleading targets for incoming missiles or weapons. In conducting mission assignments, the ship will use decoy systems primarily as a defensive measure. The major component of the ECM group is the Super Rapid Bloom Offboard Chaff (SRBOC) Mk 36 Mod 1.

CLOSE-IN WEAPON SUBSYSTEM (CIWS)

The Close-In Weapon System (CIWS) Mk 15 Mod 1 provides the final defense against antiship cruise missiles (ASCM) as part of the Navy's defense-in-depth concept. The CIWS will engage and destroy ASCMs or aircraft that penetrate a ship's primary defense envelope. The CIWS also provides ASCM and antiair defense for ships operating in other than defense-in-depth situations. The CIWS is essentially a stand-alone weapon system consisting of the Weapon Group Mk 16 Mod 1, Remote Control Panel (RCP) Mk 340 Mod 1, and Local Control Panel (LCP) Mk 339 Mod 2. The CIWS may be operated in either the antiair warfare (AAW) automatic mode or the AAW manual mode.

UNDERWATER WEAPON SUBSYSTEM

The underwater weapon subsystem provides the combat system with an engagement capability against subsurface threats. The underwater weapon subsystem is composed of the following equipment:

1. Sonar Set AN/SQS-56
2. Tactical Towed Array Sonar (TACTAS)
3. Torpedo Tubes Mk 32 Mod 5
4. Control Panel Mk 309 Mod 0

LIGHT AIRBORNE MULTIPURPOSE SYSTEM (LAMPS)

The light airborne multipurpose system (LAMPS) is a combined helicopter-ship subsystem capable of supporting both combat and noncombat missions. The primary combat missions are antisubmarine warfare (ASW) and antiship surveillance and targeting (ASST). The secondary, noncombat missions include search and rescue, medical evacuation, vertical replenishment, and utility operations.

The LAMPS consists primarily of an SH-60B Seahawk helicopter. The LAMPS helicopter is an all-weather, airborne platform capable of carrying various detection devices, including a sonobuoy receiver-transmitter for transferring sonobuoy data to the ship. Shipboard LAMPS equipment consists of a Telemetric Data Receiving Set AN/SKR-4A (SKR-4) and a Sonar Signal Processing Set AN/SSQ-28.

MISSILE/GUN WEAPON SUBSYSTEM

The missile/gun weapon subsystem enables the combat system to deliver to a target an SM-1 missile warhead or a 76-mm gun projectile. This subsystem uses internally and externally generated raw data and processed data to provide the combat system with weapon assignment, direction, and firing capability. The missile/gun subsystem supports the combat system antiair warfare (AAW), surface warfare (SUW), and antisubmarine warfare (ASW) missions.

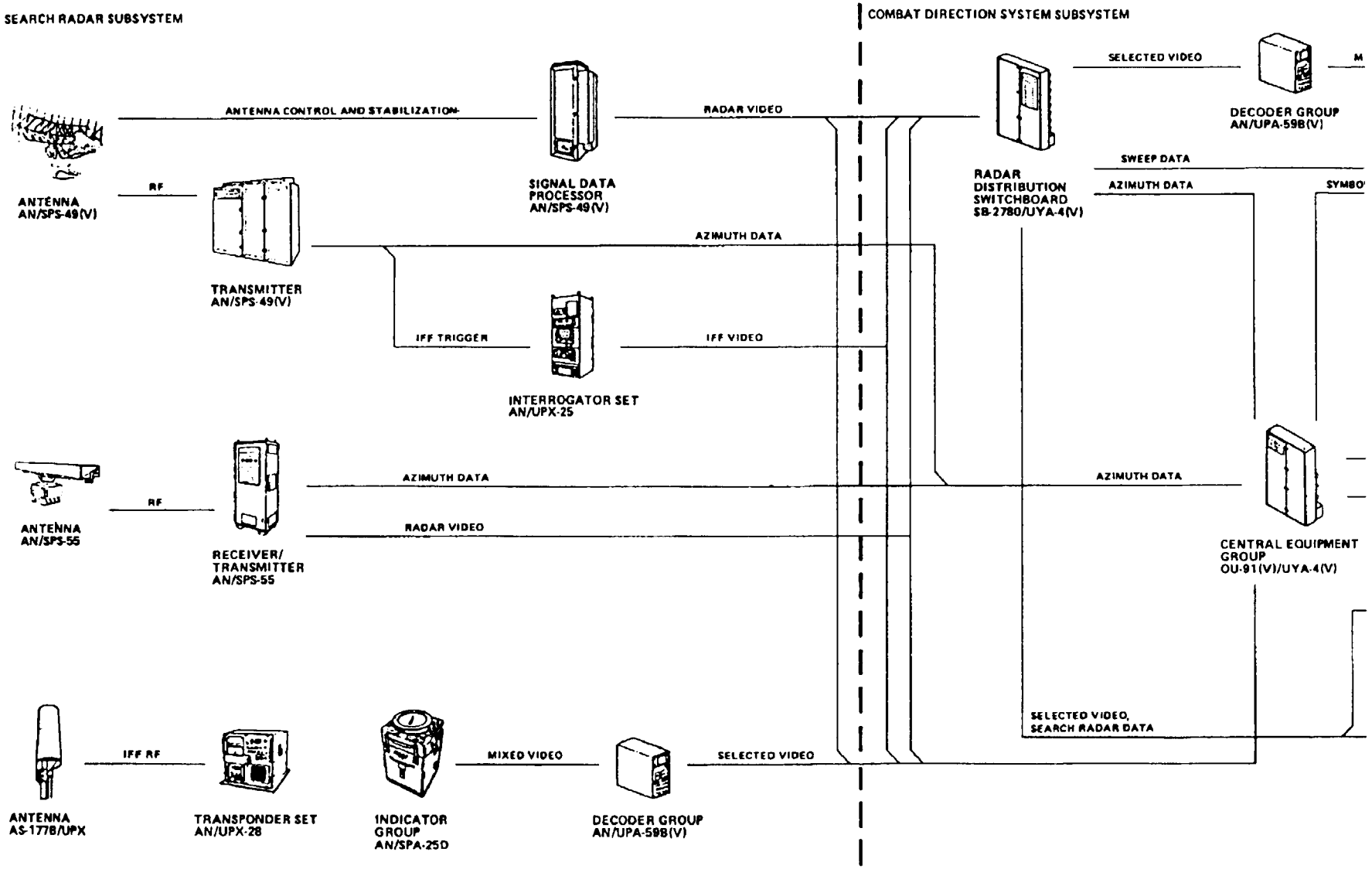


Figure 4-2.–Search radar and combat direction system subsystems.

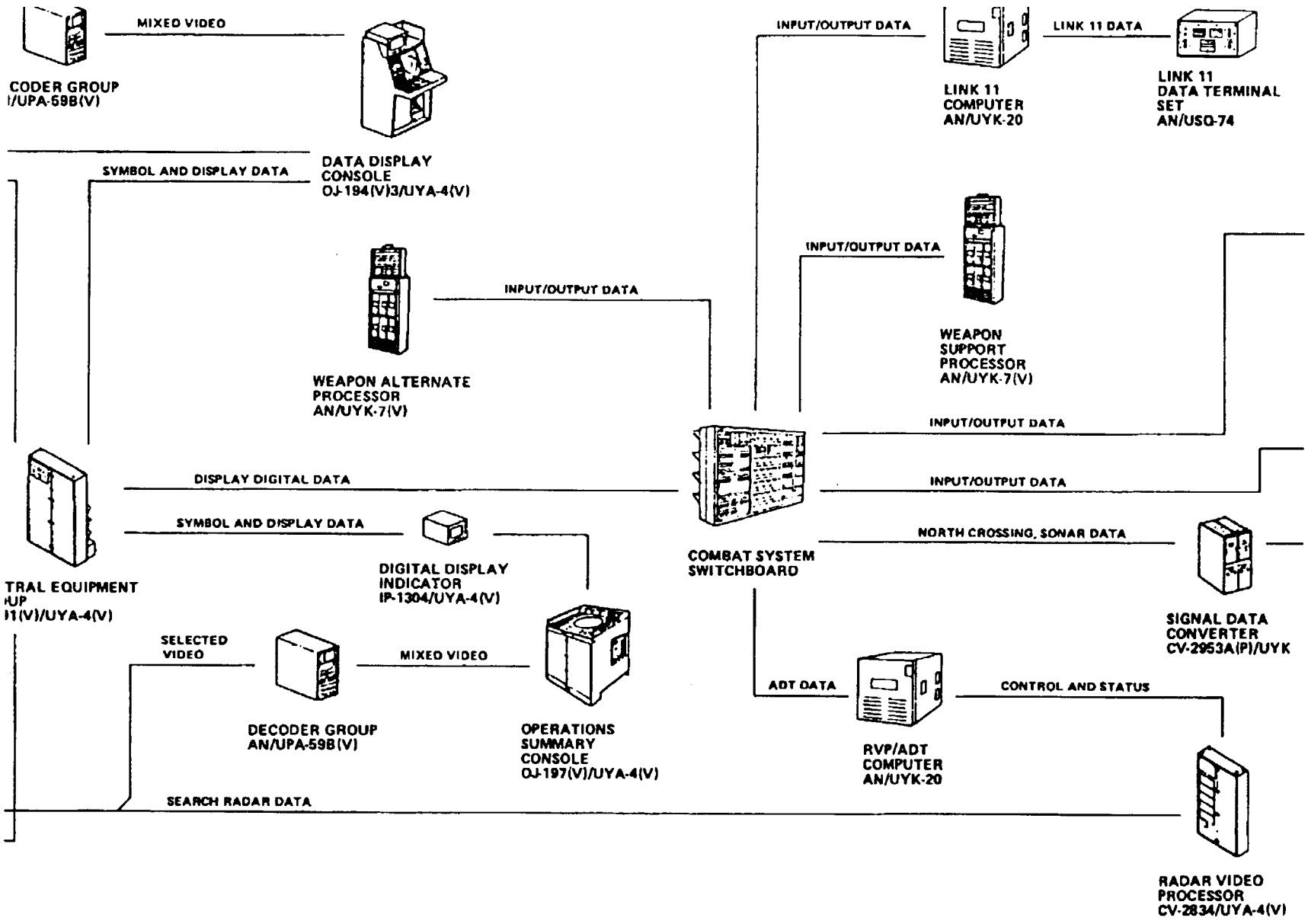


Figure 4-2.–Search radar and combat direction system subsystems–Continued.

HARPOON MISSILE WEAPON SUBSYSTEM

The HARPOON missile weapon subsystem provides a self-contained, surface-to-surface missile system capable of launching the HARPOON missile at over-the-horizon surface targets. The HARPOON missile weapon subsystem is the ship's primary surface-to-surface weapon. The subsystem relies on the weapon control processor (WCP) computer and other elements of the combat system for target detection, threat evaluation, weapon pairing, and target data functions.

EXTERNAL COMMUNICATIONS SUBSYSTEM

The external communications subsystem allows the ship to transmit and receive commands, orders, instructions, and reports. Its primary purpose is to fulfill tactical and operational command communication requirements; its secondary purpose is to meet essential administrative requirements.

The external communications subsystem includes antenna systems, transceivers, transmitters, receivers, terminal equipment, and security equipments. Several configurations may be used for transmitting or receiving with these equipments. Duplex, simplex, or receive-only operation may be used with both secure and nonsecure teletype and voice systems. Duplex operation provides simultaneous transmission and reception, and is used for specific operations involving the passing of data. Simplex operation provides communication between two stations in only one direction at a time. It is most commonly used on voice, data, and continuous wave (cw) circuits. Receive-only (broadcast method) is used for many teletype, facsimile, and continuous wave (cw) operations, where receipt acknowledgement for each message is not required.

Communication services provided by the external communications subsystem are voice, teletype, digital data, high frequency (hf and ultra high frequency (uhf) relay, and very high frequency (vhf) homing. Voice communication services are provided on the R, U, Y, vhf bridge-to-bridge and fleet satellite communication (SATCOM) secure voice, and underwater communication circuits. The terminal configurations consist of the C, G, N, R, Sa, Sd, W, and single audio system (SAS) configurations. The Naval Modular Automated Communications System (NAVMACS A+) is provided as a special facility.

The **Link 11** circuit provides for interchange of track data, weapon system status, and commands. This is done on a digital link between naval tactical data system (NTDS) ships, certain airborne early warning facilities, and antisubmarine warfare aircraft via hf or uhf. The Link 11 circuit is the primary means for

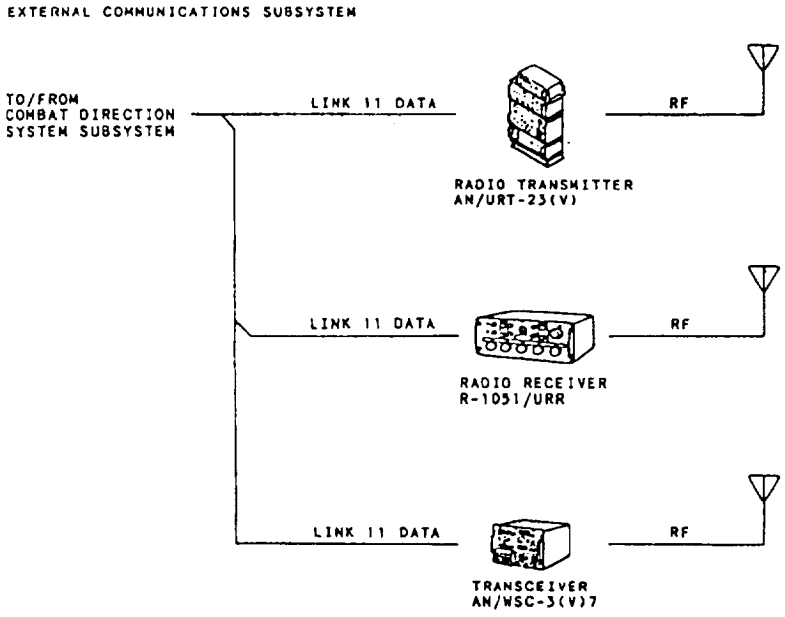


Figure 4-3.–External communications subsystem (Link 11).

intership transfer of tactical and command data. Figure 4-3 shows a pictorial diagram of the Link 11 circuit.

NAVIGATION SUBSYSTEM

The navigation subsystem provides the combat system with accurate own-ship position anywhere in the world and the navigational information needed to maneuver own ship safely. It also provides an identity-coded TACAN beacon signal to enable aircraft to determine their range and bearing in relation to own ship.

The navigation subsystem uses shipboard, shorebased, and aircraft electronic equipment to accomplish its supporting mission. The shipboard navigation subsystem is made up of the following equipment:

1. Sonar Sounding Set AN/UQN-4
2. Satellite Navigation Set AN/SRN-19
3. TACAN Set AN/URN-25
4. Dead Reckoning System

Figure 4-4 shows a pictorial diagram of the navigation subsystem.

SUPPORT SUBSYSTEM

The following systems and equipment compose the support subsystem:

1. Dry air and nitrogen
2. Liquid cooling and heating
3. Ship parameters and distribution (own-ship heading, roll, and pitch, own-ship speed and distance, and wind speed and direction)
4. Ship power and distribution
5. Air conditioning and heating
6. Interior communications

COMBAT SYSTEMS TEST AND EVALUATION PROGRAM (CSTEP)

The Combat Systems Test and Evaluation Program (CSTEP) is a combination of special teams, tests, evaluations, publications, and reports used to promote the effectiveness of shipboard combat systems. Basically, the program is designed to

1. increase the priority and focus given to combat systems during overhauls and selected restricted availabilities (SRAs);

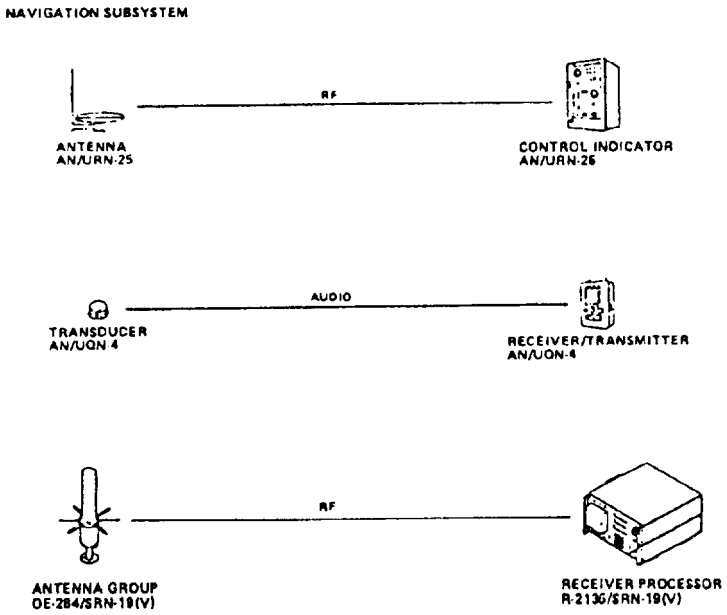


Figure 4-4.–Navigation subsystem.

2. increase the efficiency and effectiveness of combat systems evolutions that occur during a ship's life cycle schedule; and

3. provide a procedure for the intermediate unit commander (IUC) to use periodically in monitoring and assessing the combat system organization and readiness of individual units.

The overall goal of the Combat Systems Readiness Program is to develop and maintain a high combat systems readiness in each unit in the force. The specific objectives are as follows:

- Maintenance–To improve the combat systems maintenance condition of the force
- Overhaul planning–To improve the planning process for the combat system portion of overhauls and major ship restricted availabilities (SRAS)
- Overhaul–To improve the quality of work conducted on combat system equipment; to increase the focus on combat system integrated testing; and to ensure high levels of technical training during an overhaul or SRA
- Post-overhaul–To ensure maximum combat system effectiveness immediately after overhaul by taking full advantage of the basic and intermediate training associated with the overhaul or SRA
- Combat readiness–To maintain combat system equipment readiness and training at a high level throughout the entire operational cycle of each unit in the force; to provide for efficient and effective management of combat-systems-related training, administrative, and readiness programs; and to provide means to evaluate and report promptly a unit's combat systems readiness

Table 4-1 shows a typical life cycle schedule of combat systems test and evaluation program key events.

The program is composed of many subprograms, all of which are intended to increase combat systems readiness. Several of those programs are discussed below.

GROUP COMMANDERS' COMBAT COORDINATION SUPPORT TEAM (CSCST)

The Group Commanders' Combat Coordination Support Team (CSCST) assists in monitoring and assessing an individual unit's combat systems organization and readiness during all combat systems readiness evolutions. During these evolutions, the CSCST conducts ship visits to evaluate and help in the development of shipboard programs to improve combat system readiness. Until permanent CSCST detachments are formed in individual home ports, group commanders form CSCSTs from assets within the group and the ship's home port. Specifically, CSCST takes the following actions:

- Reviews combat system administrative support (for example, technical manuals, CSTOM, COSAL, PMS, GPETE), assesses progress during overhauls and ship restricted availabilities, conducts reviews of the Combat Systems Integrated Test Plans (CSITP), and supports CSPOE/CSORE. (See CSTEP events 2 and 3 below.)
- Evaluates and, when required, conducts technical training to improve ship's force ability to light off, test, operate, and maintain combat systems equipment.
- Evaluates the effectiveness of the Ship's Electronic Readiness Team (SERT).
- Assists in conducting the following CSTEP events:
  - Combat Systems Pre-Overhaul Assessment (CSPOA)
  - Combat Systems Post-Overhaul Examination (CSPOE)
  - Combat Systems Operational Readiness Examination (CSORE) (Phases I and II)

NAVSEACEN COMBAT SYSTEMS READINESS ASSISTANCE

NAVSEACEN provides engineering technical support and material services to forces afloat. They assist in conducting Combat Systems Readiness Reviews (CSRR) and provide gun/missile/ASW battery and gunfire control/missile fire control/ASW fire control technical assistance. These reviews are not the same as the technical assistance for repairs provided by MOTUs, but instead provide assistance necessary to further the "self-reliance" of the ship's force in improving the operational readiness of installed ordnance.

Table 4-1.–Typical Life Cycle Schedule of Combat Systems Test and Evaluation Program Key Events

EVENT	TIMING
Pre-Overhaul Test & Inspection (POT&I) Phase I	Start ROH - 12 months
Pre-Work Definition Conference Meeting (Pre-WDC)	Start ROH - 7 months
Work Definition Conference (WDC)	Start ROH - 6 months
Forces Afloat Work Definition Conference (FAWDC)	Start ROH - 3 months
Immediate Unit Commander Pre-Overhaul Assessment (POA)	Start ROH - 4 weeks
Overhaul Activity Deliver ITP to Ship	Start ROH + 6 weeks
Ship Force/Overhaul Activity Complete ITP Review	Start ROH + 25%
Combat Systems Coordinated Support Team (CSCST)	Start ROH + 60%
Commence Combat Systems Level Testing	Start ROH + 75% or End -12 Weeks
Combat Systems Post Overhaul Examination (CSPOE)	As soon as practicable after ROH usually 2-3 weeks after
Training Readiness Evaluation (TRE)	End ROH + 5 weeks
Combat Systems Ships Qualification Trials (CSSQT)	End ROH + 9 weeks
Weapons System Accuracy Trials/Fleet Operational Readiness Accuracy Checks (WSAT/FORAC)	End ROH + 14 weeks
DMSR	Before sail for RFT
Refresher Training (RFT)	End ROH + 15 weeks
Naval Gunfire Support Qualifications (NGFS)	End ROH + 21 weeks
Combat Systems Operational Readiness Examination (CSORE) Phase I	5 months before deployment (NOTE 1)
Combat Systems Operational Readiness Examination (CSORE) Phase II	4 months before deployment
Combat Systems Readiness Review (CSSR)	Before deployment
Combat Systems Operational Readiness Examination (CSORE) Phase III	2 months before deployment
Deployment	End ROH + 40 weeks
Command Assessment of Readiness and Training (CART) Phase I	During deployment
Command Assessment of Readiness and Training (CART) Phase II	End deployment + 5 weeks
Interim Refresher Training (IRFT) (As Required)	End deployment + 12 weeks
Naval Gunfire Support Qualifications (NGFS)	End deployment + 16 weeks
Combat Systems Operational Readiness Examination (CSORE) Phase I	5 months before deployment
Combat Systems Operational Readiness Examination (CSORE) Phase II	4 months before deployment
Combat Systems Readiness Review (CSRR)	Before deployment
Combat Systems Operational Readiness Examination (CSORE) Phase III	2 months before deployment
NOTE 1: New construction ships will enter the CSTEP at CSORE I before the initial deployment.	

COMBAT SYSTEMS READINESS REVIEW (CSRR)

The Combat Systems Readiness Review (CSRR) is a comprehensive program developed to help the ship's force achieve a high state of combat systems readiness for deployment. Implicit in this goal are the following objectives:

- To assess the readiness of the ship's combat systems material and personnel and to report the status to appropriate seniors
- To help ship's force and IUCs correct material problems
- To provide on-the-job training for ship's force personnel and to improve the ship's self-sufficiency

ORDNANCE SPECIAL ASSISTANCE TEAM (ORDSAT)

The Ordnance Special Assistance Team (ORDSAT) consists of several technicians, both military and civilian, highly trained in various fire control systems. The team's primary purpose is to instruct the ship's force in how to maintain its own equipment, thereby improving its battery system as a whole. Ordnance equipment includes: gun battery, gunfire control, guided missile tire control, and underwater battery fire control systems.

COMBAT SYSTEMS OPERATIONAL READINESS EXAMINATION (CSORE)

The Combat Systems Operational Readiness Examination (CSORE) is an evaluation conducted in three phases by the ship's IUC to determine the material readiness, personnel training level, and logistic support of the installed combat system.

COMBAT SYSTEMS POST-OVERHAUI. EXAMINATION (CSPOE)

The Combat Systems Post-Overhaul Examination (CSPOE) is an evaluation of the combat system readiness and training of the ship. It provides prerequisite testing and preparation for CSSQT, WSAT, and RFT; evaluates equipment readiness and the ability of the ship's force to light-off, operate and maintain equipment; and assesses the combat system technical training.

COMBAT SYSTEMS SHIP QUALIFICATION TRIALS (CSSQT)

The Combat Systems Ship Qualification Trials (CSSQT) is a series of comprehensive tests and trials designed to show that the equipment and systems included in the CSSQT program meet combat system requirements. It also provides training and familiarization to ship personnel in maintaining and operating installed equipment, identifies design problems, and determines deficiencies in support elements (for example, documentation, logistics, test equipment, or training).

OVERALL COMBAT SYSTEMS OPERABILITY TEST (OCSOT)

The Overall Combat Systems Operability Test (OCSOT) is a Level 1 PMS test designed to provide the commanding officer with an operational assessment of the total combat system.

COMBAT SYSTEMS IMPROVEMENT PROGRAM ADVISORIES (CSIPs)

The Combat Systems Improvement Program advisories (CSIPs) are numbered advisories used by the type commander to pass on to units lessons learned, recommendations, and specific guidance about combat systems requirements.

COMBAT SYSTEMS INTEGRATED TEST PLAN (CSITP)

The Combat Systems Integrated Test Plan (CSITP) consists of detailed procedures for conducting all combat system tests through the systems level during overhaul *(Combat Systems Test and Certification Manual,* NAVSEA T9073-AB-TRQ-010]).

COMBAT SYSTEM TEST TASK GROUP (CSTTG)

The Combat System Test Task Group (CSTTG) is made up of representatives from the ship's force, the shipyard, SUPSHIP, and other commands, as appropriate. This group monitors the CSITP (NAVSEA T9073-AB-TRQ-010).

COMBAT SYSTEMS TEST COORDINATOR (CSTC)

The Combat Systems Test Coordinator (CSTC) is the ship's representative to the Combat System Test Task Group. The CSTC is responsible for coordinating all testing with the shipyard and for making sure that all testing is completed and involves the full ship's force (NAVSEA T9073-AB-TRQ-010).

COMBAT SYSTEMS TRAINING REQUIREMENTS MANUAL (CSTRM)

The Combat Systems Training Requirements Manual (CSTRM) is a manual, developed for each class of ships in the force, that specifies the standards of technical and operational training expected for all operators and technicians.

COMBAT SYSTEMS TRAINING TEAM (CSTT)

The Combat Systems Training Team (CSTT) consists of the most experienced shipboard personnel. It is responsible for training combat systems personnel in operating and maintaining installed equipment, and for supervising combat systems related exercises.

COMBAT SYSTEMS TROUBLED EQUIPMENT ACTION PROGRAM (CSTEAP)

The Combat Systems Troubled Equipment Action Program (CSTEAP) is used by the TYCOM staff to identify, investigate, improve, and monitor combat systems equipment installed on TYCOM units that causes chronic problems.

ORDNANCE HANDLING SAFETY ASSIST TEAM (OHSAT)

The Ordnance Handling Safety Assist Team (OHSAT) is a group of ordnance handling experts that visits the ship periodically to monitor the security of arms, ammunition, and explosives (AA&E). The team also audits safety practices and material conditions associated with the handling, storage, and use of conventional weapons.

WEAPON SYSTEM ACCURACY TRIALS (WSATs)

Weapon System Accuracy Trials (WSATs) are tests and trials designed to prove the accuracy of the ship's antisubmarine warfare (ASW) system.

The previous portion of this chapter has basically described the various subsystems of one ship class combat system. As you can see, all subsystems are very important to the readiness of the overall combat system. As a senior technician and supervisor, you must work with your fellow combat systems technicians, supervisors, and operators to ensure a high state of combat system readiness.

COMBAT SYSTEM TECHNICAL OPERATIONS MANUAL (CSTOM)

Sophisticated combat system integration is rapidly replacing single-systems operations on ships. To help ships adopt and maintain the new concept, the CNO has directed that all ships with tactical data systems be provided with a Combat System Technical Operations Manual (CSTOM). The CSTOM provides the crew with all aspects of integrated combat systems.

The Class-of-Ship CSTOM contains and organizes the technical data that shipboard personnel need to (1) operate and maintain the integrated combat system; (2) maintain material and personnel readiness; and (3) define significant capabilities and limitations of the combat system.

The CSTOM also performs the following functions:

1. Specifies and explains how systems and subsystems are integrated

2. Defines the readiness requirements for operational and maintenance personnel

3. Establishes the Ship Electronic Readiness Team (SERT) to maintain on-line combat system readiness

4. Provides text and graphic materials to be used for both classroom training and self-instruction. Pictorial diagrams, rather than conventional block diagrams provide more realistic training. Data are presented in levels ranging from elementary to detailed, allowing presentations to be made at the appropriate educational level.

To give you an idea of what is contained in a CSTOM, we will use the FFG-7 class CSTOM as

an example. The CSTOM is organized into volumes and chapters as shown below:

VOLUME l–COMBAT SYSTEM DESCRIPTION

Chapter 1–Introduction

Chapter 2–Combat System Descriptions

Chapter 3–Combat System Operational Description

VOLUME 2–OPERATIONAL PROCEDURES

Chapter 4–Operational Procedures

VOLUME 3–COMBAT SYSTEM READINESS

Chapter 5–Readiness Assessment

Chapter 6–Fault Detection and Impact Evaluation

Chapter 7–Fault Isolation

VOLUME 4–CAPABILITIES AND LIMITATIONS

Chapter 8–Ship Mission Capabilities and Limitations

Chapter 9–Detection Capabilities and Limitations

Chapter 10–Threat Processing Capabilities and Limitations

Chapter 11–Threat Evaluation and Weapon Assignment Capabilities and Limitations

Chapter 12–Engagement and Engagement Assessment Capabilities and Limitations

Chapter 13–Cover, Deception, and Emission Control Capabilities and Limitations

Chapter 14–Communications Capabilities and Limitations

Chapter 15–Introduction to Navigation Capabilities and Limitations

Chapter 16–Introduction to Underway Replenishment Capabilities and Limitations

SHIP ELECTRONICS READINESS TEAM (SERT)

Recall that the CSTOM assigns to the SERT the responsibility for maintaining on-line combat system readiness. Administratively, the SERT reports to the system testing officer (STO). The STO, in turn, reports to the combat system officer (CSO) as shown in figure 4-5. In the following paragraphs, we will discuss the SERT somewhat in detail, both what it is and what it does. If your ship has a SERT, the discussion will help

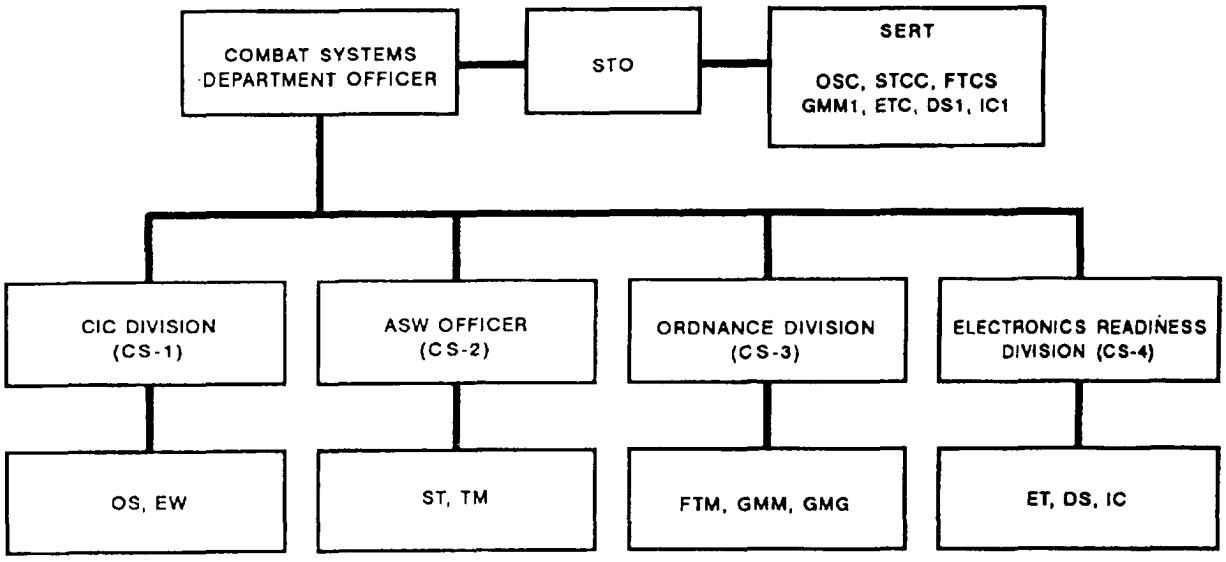


Figure 4-5.–Combat system department organization.

you understand its purpose. If your ship does not yet have a SERT, you may want to use some of the SERTs procedures within your area of responsibility.

SERT Training

The SERT is trained as a unit in the combat system's operation, preventive and corrective maintenance, maintenance management, and training using the combat system technical operations manual (CSTOM) as the basic reference.

The SERT members should have knowledge in the following areas, either by previous formal training or by a rigorous shipboard training program (may be accomplished within the SERT):

- PMS philosophy
- PMS scheduled and corrective maintenance
- Planned maintenance during overhaul
- Maintenance data system
- Combat system, subsystem, and equipment operation
- Ship alteration, ordnance alteration, and field change cofiguration levels
- Combat system, subsystem, and equipment maintenance; and maintenance scheduling
- Ordnance pamphlets, ordnance data, and NAVSEA manuals
- Combat system, subsystem, and equipment tests
- Logistic support

Members of the SERT (fig. 4-6) are senior petty officers who have extensive experience in subsystem and equipment maintenance. Each must be an expert on at least one subsystem. Since the SERT is an official part of the ship's organization, the duties of the members are primary, not collateral.

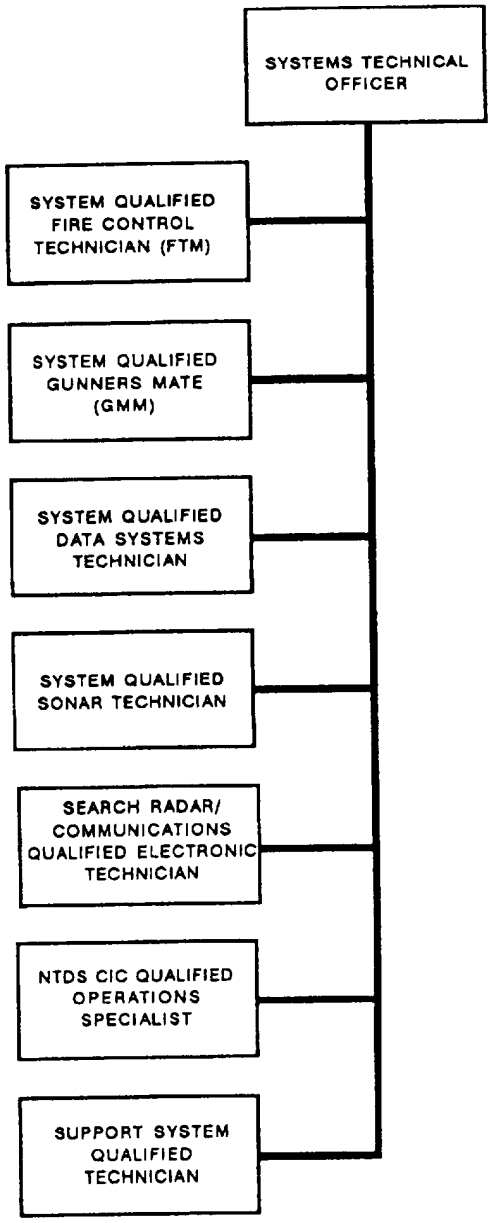


Figure 4-6.–Ship electronic readiness team organization.

SERT Operations

For the SERT to coordinate preventive and corrective maintenance efforts effectively, there must be extensive coordination and cooperation between the major branches of the combat system department. The SERT should have direct access to the leading petty officers of each subsystem group within the combat system department. Additionally, because the combat system does not include all maintenance and operational departments of the ship and because the combat system cannot operate without the support of the other departments, all departments should be involved in implementing a system-level maintenance program. **Both** officers and enlisted personnel should participate in the scheduling process for the plan.

For the SERT to be held responsible for combat system readiness, it must have clearly defined responsibilities and authority. This is best done by a specific shipboard instruction.

SERT authority should be in the area of organization, as well as in material and personnel readiness.

So all personnel can quickly understand combat system availability during condition I, condition HI, and in port, the SERT should establish the following lines of communication:

1. During **Condition I** (general quarters), the STO should be assigned a general quarters station in the combat information center (CIC). He should be able to inform the tactical control officer (TCO) of the present and changing status of combat system availability (on a threat basis). The rest of the SERT should be assigned as roving evaluators for subsystems with which they are most familiar. If possible, the roving evaluators' duties should be rotated so SERT members become familiar with all areas without affecting the overall operation of the combat system.
2. During **Condition III,** at least one SERT member should be on watch in the CIC, with the responsibility of reporting combat system status to the TAO. The rest of the SERT should do their regular duties of testing, instructing, and evaluating maintenance activities.
3. **In port,** at least one SERT member should be assigned to each duty section so the command duty officer will know the actual system status at all times. The knowledge SERT personnel have must not be confined to a particular subsystem if the organization is to function properly during condition III and in port.

SERT Responsibilities

Responsibilities of the SERT are broadly defined as maintenance management, readiness assessment, and operational training guidance required to ensure high-level combat system readiness. Specific responsibilities of SERT include:

- Integrating and managing PMS for the combat system
- Determining mission-related materiel readiness
- Managing the corrective maintenance effort for the combat system including fault isolation, and data collection and analysis
- Monitoring operational performance during condition watch exercises and ship or fleet operational exercises
- Evaluating both materiel and operational readiness of the combat system, and providing internal or external reports as necessary

PMS Management

PMS management, one of the major functions of the SERT, includes supervision of actual maintenance actions and all other efforts required to plan and support maintenance events. Therefore, the management task involves controlling all combat system PMS activities, including PMS tasks for the combat system, subsystems, and equipment. The SERT provides the foundation for maintenance through proper planning and execution.

Certain PMS procedures at the combat system level are more oriented toward operator proficiency, with summary observation of combat system performance. The management guidance in the PMS manual and the Cycle and Quarterly Schedules are primarily equipment- and department-oriented. This guidance provides minimum maintenance requirements for the subsystems and equipment covered under PMS. The SERT must manage within such factors as the interdependence of equipment and subsystems within the combat system, the variations of available manpower, and the dedication of subsystems to operations during conditions I and III.

The scheduling and performance of PMS (supported by documentation and maintenance training) leads to fault detection, which provides a basis for readiness assessment. Maintenance management ensures that detected faults are isolated and followed by corrective action. Effective corrective maintenance includes logistic control and the determination of how important each corrective maintenance requirement is, based on parts availability and readiness assessment. Follow-up action, including verification or retesting, and complete shipboard and maintenance data collection reporting for the subsystems close the loop.

MATERIEL READINESS ASSESSMENT

Materiel readiness assessment involves performing tests and operational checks on the system to identify equipment that is either degraded or nonoperational. The results of the tests and operational checks are then used to determine how well the system can perform its

mission requirements. Readiness assessment is probably the most difficult task facing the SERT because it requires the ability to provide an up-to-the-minute status of the combat system capabilities and limitations. It also requires the ability to recommend alternate combinations of equipment to meet mission needs. The SERT must know the results of all tests and, in addition, the minute-to-minute availability of the combat system, its subsystems, equipment, and all support functions, such as primary power, chilled water, dry air, and sound-powered telephones. Readiness assessment is directed toward four major missions: antiair warfare, antisubmarine warfare (ASW), antisurface ship warfare, and amphibious warfare.

Although all problems with equipment are important, the existing tactical environment can modify their impact on a mission capability. For example, loss of moving target indicator capability can be more important when the ship operates close to land masses than when it operates in the open sea.

Materiel readiness assessment should be approached from the functional readiness aspect (how well it works) rather than the equipment up or down status aspect (whether or not it works) for the following reasons:

- Complex, multifunction electronic equipment is seldom completely down and less frequently completely up. Normally, one or more functions are in various states of degradation.
- The impact of a functional fault may be different for each mission's capability.
- The combat system's complex design includes some functional redundancy.
- The test results and operational fault directories relate problems to their effect on system functions rather than to the basic operation of the affected equipment.

Readiness assessment uses two basic types of techniques, quantitative and qualitative. Quantitative techniques involve the extensive use of mathematics and reports based on graphs and numbers. Past shipboard experience has shown that without computer support, quantitative assessment is not easily managed. Its numerical reporting lacks meaning or requires extensive explanation. Qualitative assessment (an application of engineering analysis) is based on system knowledge, experience, and judgment; and normally is reported verbally.

Qualitative assessments depend on the personal experience level of the users; therefore written guidance and report forms are needed. The impact of no-go conditions, revealed by PMS results, must be determined for each mission capability.

After an assessment is made, each major function is assigned one of the following readiness criteria:

1. Fully combat-ready
2. Substantially combat-ready
3. Marginally combat-ready
4. Not combat-ready

Fully combat-ready status indicates that all equipments associated with that function are in the highest state of readiness with respect to that function.

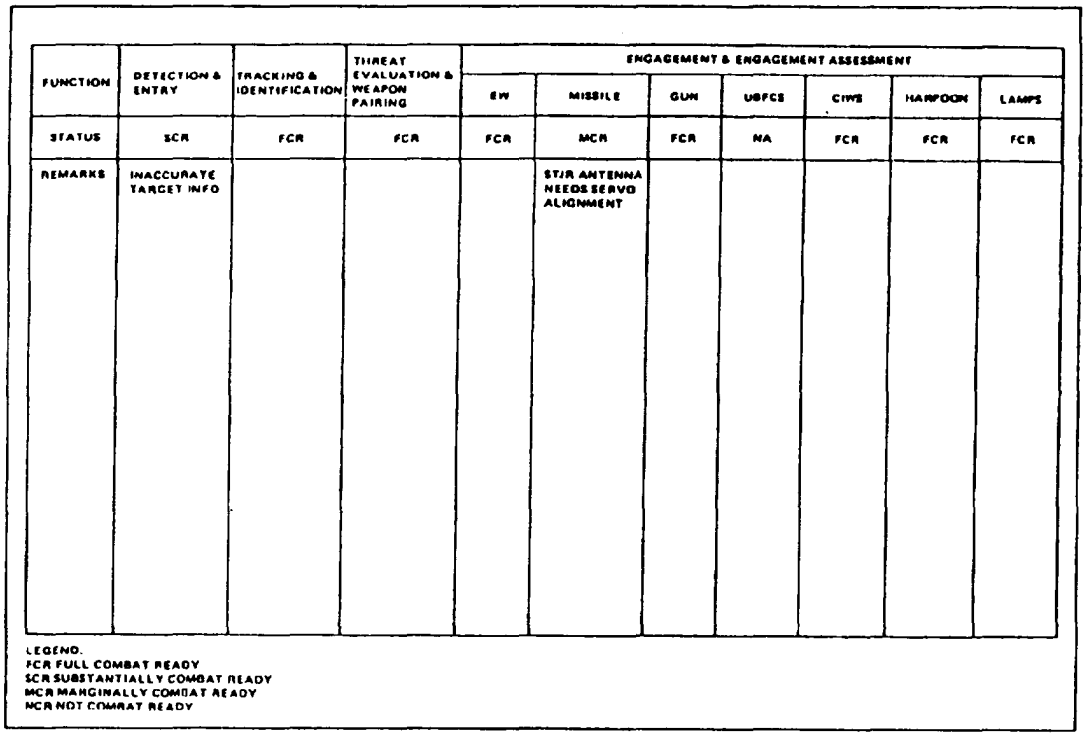
Substantially combat-ready indicates that, although all equipments may not be fully operational, redundancy permits the mission to be continued, with a high probability of success.

Marginally combat-ready indicates a function that can be performed, but with a much reduced probability of success.

Not combat-ready indicates complete loss of function.

These readiness criteria provide the basis for a summary report of readiness in each mission capability. The mission summary report (fig. 4-7) should be supported by a combat system daily fault report (fig. 4-8) listing the subfunction faults of the day, their individual impact, alternative recommendations, and expected time of repair.

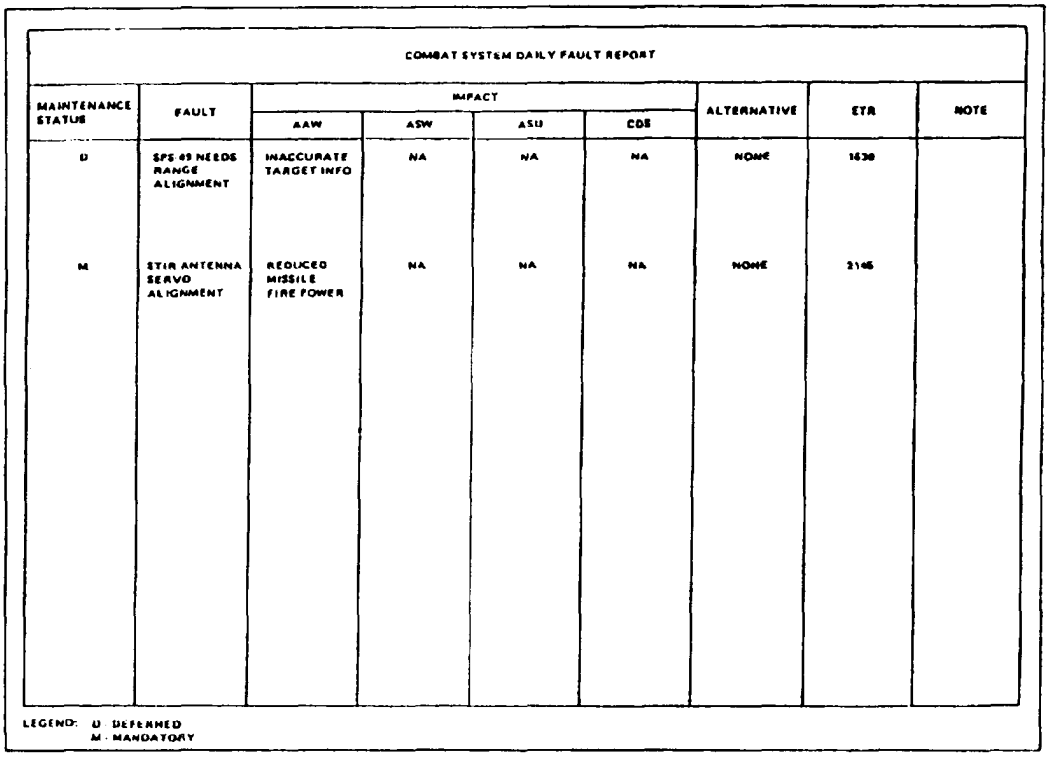
Materiel readiness does not end with successful completion of tests and scheduled maintenance. In addition to testing, other actions such as visual inspection for cleanliness, corrective maintenance, quality control, and complete integrity are a necessary part of SERT responsibilities. Also, having the commanding officer conduct materiel inspections, assigning SERT personnel to inspection teams, and conducting random equipment inspections without prior notice can provide excellent results. Such inspections should be for electronic and mechanical materiel readiness and preservation. The SERT representatives should also provide results of such inspections to appropriate authorities and provide follow up inspections to ensure that corrective action is taken.



FUNCTION	DETECTION & ENTRY	TRACKING & IDENTIFICATION	THREAT EVALUATION & WEAPON PAIRING	ENGAGEMENT & ENGAGEMENT ASSESSMENT						
				EW	MISSILE	GUN	USFCS	CIWS	HARPOON	LAMPS
STATUS	SCR	FCR	FCR	FCR	MCR	FCR	NA	FCR	FCR	FCR
REMARKS	INACCURATE TARGET INFO				STIR ANTENNA NEEDS SERVO ALIGNMENT					

LEGEND.
FCR FULL COMBAT READY
SCR SUBSTANTIALLY COMBAT READY
MCR MANGINALLY COMBAT READY
NCR NOT COMBAT READY

Figure 4-7.–Mission Summary Report.



COMBAT SYSTEM DAILY FAULT REPORT

MAINTENANCE STATUS	FAULT	IMPACT				ALTERNATIVE	ETR	NOTE
		AAW	ASW	ASU	COS			
D	SPS 49 NEEDS RANGE ALIGNMENT	INACCURATE TARGET INFO	NA	NA	NA	NONE	1630	
M	STIR ANTENNA SERVO ALIGNMENT	REDUCED MISSILE FIRE POWER	NA	NA	NA	NONE	2145	

LEGEND: D DEFERRED
M - MANDATORY

Figure 4-8.–Combat System Daily Fault Report.

CORRECTIVE MAINTENANCE MANAGEMENT

Corrective maintenance consists of two basic categories, fault isolation and corrective action. The SERT is responsible for directing fault isolation at the combat system level, managing corrective maintenance at all combat subsystem levels, and coordinating corrective maintenance in related support subsystems. The SERT responsibility for corrective maintenance also includes coordinating fault isolation efforts and evaluating the impact of faults to determine the priority of each corrective maintenance requirement. Another responsibility includes follow-up action of verification or retesting, and complete shipboard and maintenance data collection subsystem reporting.

Effective corrective maintenance management first requires the consideration of combat system readiness, then efficient use of manpower. These factors closely relate to the ship's employment and the tactical environment. There will be times when more corrective maintenance requirements exist than can be simultaneously handled by the available manpower. In addition, sometimes parallel faults exist that require the same personnel or the same system setup for fault isolation. When these conditions occur the setting of repair priorities is based on management's requirements for readiness and manpower available to make the repairs. As the SERT collects and evaluates PMS results, it should continually base its recommendations for correcting faults on the tactical situation, complexity of fault isolation, and available manpower. Some faults may be designated for correction; others may be deferred. However, faults that are deferred, if left to accumulate, tend to degrade overall system readiness. Therefore, as soon as the situation permits, deferred faults should be repaired.

Faults detected within the combat system must be isolated to a subunit that can be replaced or repaired or to an alignment that can be made before actual corrective action can be taken. This requires technicians to have a thorough knowledge of the system and access to complete system and equipment documentation. Most subsystem and equipment maintenance publications provide fault isolation support in one or two formats. The first format consists of symptoms presented in preselected, logical steps and in reference tables, a logic chart, or logic diagram format. The second format consists of flow diagrams and relay ladders. The CSTOM provides amplifying information on fault isolation.

After a repair priority has been set and the faults isolated, the managers of corrective maintenance must ensure corrective action is taken, verification is made by retest, and required reports are completed. Since some faults tend to be repetitive, the SERT should keep records of fault symptoms, identification, and corrective measures.

MONITORING OPERATIONAL READINESS

Since overall readiness assurance is a function of operational readiness (personnel proficiency) and materiel readiness, the SERT responsibility for operational training is very important. The goal of operational readiness is to achieve maximum combat system capability for each mission under constant] y changing conditions of materiel readiness. The measurement of personnel readiness is based on the three following techniques:

1. The use of PMS tests
2. The use of simulators or computer programs
3. The monitoring of ship or fleet exercises

In each case, the hardware must be operating properly. Otherwise, the capabilities of the personnel cannot be determined accurately.

The video signal simulator with computer programs provides a means to assess the skill of the console operator. However, the computer programs are limited in assessing the capabilities of combat system operators.

One way to evaluate the capability of all combat system personnel is to actually monitor ship or fleet exercises (described in COMTAC publications FXP-1, -2, and -3). These exercises include:

- Electronic warfare exercises
- Gunnery exercises (anti air [AA], surface, and shore)
- Missile exercises (AA and surface)
- CIC exercises (aircraft, tracking and control)
- Antiship cruise missile exercises
- ASW exercises

When the SERT finds personnel deficiencies, it must provide operational training and guidance. Since the SERT has the knowledge and training capability, it is uniquely qualified to assist the ship's training officer in identifying the topics and content of necessary training for both officers and enlisted personnel.

Whenever you evaluate the operational readiness of your personnel, you should ensure that they are familiar with the following topics:

- Intended purpose of all switches, indicators, controls, and the impact each has on other subsystems or combat system equipments
- Communication links available at the station and with the other stations
- Knowledge of and compliance with specified communication disciplines
- Knowledge that the lack of communication discipline is an internal hazard to the combat system or to the ship

TEST SELECTION AND SCHEDULING

With the coming of PMS, an integrated approach to testing was developed. This approach is based on defining all functional test requirements and subjecting them to a critical examination. The examination involves an engineering analysis in which each function, parameter, and characteristic is examined for its (1) importance to mission or mode performance, (2) reliability based on the circuit elements that affect the function and (3) expected mean time between failures. This places a test periodicity (daily, weekly, monthly, quarterly, semiannually, annually, and cyclically) on the functions. Critical functions are assigned a high periodicity, regardless of reliability; while less critical functions may be assigned a lower periodicity based on their reliability. Related functions are grouped by periodicity and functional interdependency so that they may be tested by appropriate periods. This integrated testing concept results in a management problem that is a SERT responsibility.

The tactical situation governs how and when maintenance is scheduled. Scheduling is a critical element of preventive maintenance management and requires a thorough knowledge of the intent and conditions of each maintenance requirement card (MRC). Important conditions include in-port and at-sea requirements, outside service requirements, navigational support requirements, combat system operational usage, ship control requirements, emission control conditions, computer program requirements, subsystem interdependency, impact on computer program capability, adverse weather conditions, time requirements, and manpower requirements. From these conditions, the quarterly schedule can be developed based on the ship's employment schedule. Heavy maintenance is usually scheduled during in-port periods and independent ship exercises during nonthreat conditions (particularly for those procedures requiring long periods of operational equipment downtime). If the employment schedule changes, the PMS schedule may require modification. Daily and weekly schedules are based on the ship's readiness condition and operational situation. Subsystem interdependence and manpower usage are also critical in scheduling.

Preventive maintenance management includes the following requirements:

1. Ensuring that events take place as scheduled
2. Coordinating manning and equipment availability for interdependent testing
3. Providing adequate safety measures
4. Ensuring the availability of required supporting systems
5. Coordinating the actions of command and tactical operation personnel
6. Ensuring fault isolation and corrective maintenance follow-up
7. Ensuring the completion of required reports

The ship's CSTOM contains readiness assessment and fault isolation diagrams indicating the test that requires the fewest ship resources, verifies each combat system interface function, and aids the SERT in preventive maintenance management.

READINESS ASSESSMENT REPORTING

After readiness assessment is completed, readiness status must be reported in a form that is brief and easily understood and that presents a clear picture of the combat system effectiveness. This is done most effectively by addressing the status of a major function as it relates to a mission capability. Figure 4-7 shows a sample method of presenting a mission summary report of a four-state qualitative functional readiness assessment. This summary report sample also provides a brief description of the effect each subfunction fault has on the major fictional. Supporting information on specific subfunction faults related to the summary report sample can be provided in a combat system daily fault report form. Figure 4-8 shows a sample method of presenting daily fault information. Report forms of this type (or a similar type) should be developed by the SERT to fit the ship's requirements. The combat system daily fault report is the responsibility of the SERT and should

provide enough information for the CSO to develop the mission summary reports.

The SERT must evaluate, monitor, and report system status during competitive and fleet exercises. This includes organizing and instructing observers, preparing recording forms, defining data requirements, collecting and evaluating data, and preparing a composite internal report. These reports should be limited to an evaluation of combat system materiel and personnel readiness during the exercise.

ALIGNMENT LOGS

During PMS activities and exercises, the SERT is responsible for determining the mechanical and electrical alignment of interrelated combat system functions. The SERT must also assess the impact of a misalignment on the mission. When SERT members brief subsystem and equipment personnel before an exercise or mission, they must emphasize the need for caution when making adjustments to equipment subsystems that may in turn affect the total combat system alignment. Alignment tests and efforts to reestablish reference standards are complex and time-consuming. They frequently require shore facilities, ideal environmental conditions, and extensive data collection. Technicians should avoid making realignments that, because of incomplete or inaccurate reference data, result in inefficient use of manpower and resources. Experience has shown that unnecessary alignment efforts can be avoided if reference data are kept current, accessible, and in a form that can be interpreted by all team members. Therefore, a combat system alignment smooth log (if not already in effect) must be maintained and kept current and accurate. A total combat system alignment manual for the class of ship (with combat system) should be available (separate from CSTOM). The manual should explain the purpose of total combat system alignment, provide management data needed for the analysis and troubleshooting of alignment problems, and provide step-by-step procedures needed for combat system alignment.

INTEGRATED MAINTENANCE CONCEPTS

This section of the chapter describes the planned maintenance system (PMS) as it relates to the maintenance documentation of a typical integrated combat system.

PLANNED MAINTENANCE SYSTEM

Combat system readiness requires efficient maintenance. The key to this capability is an organized system of planned maintenance that is designed to ensure the maximum operational readiness of the combat system. The OPNAVINST 4790.4, *Ships' Maintenance and Material Management (3-M) Systems,* sets forth an effective PMS and assigns PMS management responsibility.

The PMS provides regularly scheduled tests to detect degraded performance and prevent failures (preventive maintenance) during tactical operations. When failures occur during combat system operations, the PMS provides a formal step-by-step fault isolation and repair procedure (corrective maintenance). Complete technical documentation, including combat system, subsystem, and individual equipment manuals, is an integral part of the PMS. These manuals provide the necessary information for understanding, operating, and maintaining the combat system.

Shipboard maintenance falls into the three following categories:

1. Maintenance within the capability of ship personnel (organizational level)
2. Maintenance requiring assistance from outside the ship (intermediate level) such as a tender or mobile technical unit
3. Maintenance requiring port facilities (depot level) such as shipyard maintenance

Since the goal of PMS is to perform maintenance on the organizational or intermediate level, depot level maintenance is not reflected in PMS.

The PMS is a planning and control system that prescribes a logical and efficient approach to complex mechanical, electrical, and electronic maintenance. The PMS was developed to provide supervisors at each maintenance level with methods for effectively planning, scheduling, and controlling shipboard maintenance. It includes a maintenance data collection system used to record important scheduled and corrective maintenance information, and electronic data processing capabilities used to retrieve this information for maintenance analysis.

You should already be familiar with the 3-M Systems at this point in your career as an ET; however, we will summarize the planned maintenance system and will then add information on the integrated combat system concept.

As you well know, the goal of PMS is maximum operational efficiency of all equipments and the reduction of equipment downtime, maintenance manhours, and maintenance costs. Even though the PMS provides methods and resources to accomplish each goal, it is not self-sufficient and does not replace the initiative of maintenance supervisors nor reduce the need for technically competent personnel. Recording and feedback of maintenance and personnel data allow continuing management analysis and improvement of maintenance methods and personnel use. If the ship's force accepts the PMS program and makes full use of its planning methods, the maintenance system will promote confidence and reliability, and will be capable of ensuring that the combat system will be available when it is needed.

Data gathered from the fleet show conclusively that ships that adhere to their PMS schedule maintain a significantly higher state of materiel readiness with no greater maintenance manpower usage than ships that do not. The SERT concept is designed to ensure that the combat system PMS is properly scheduled, managed, and used.

PMS PROGRAM (COMBAT SYSTEMS)

The primary ingredients of the PMS program areas follows:

- Comprehensive procedures for planned maintenance of the combat system, subsystems, and equipments
- System fault isolation procedures
- Scheduling and control of maintenance task performance
- Description of the methods, materials, tools, and personnel required for maintenance

Adherence to the PMS program will provide the following results:

- Improved confidence in system maintenance
- Reduced testing time
- Elimination of redundant testing resulting from lack of coordination
- Detection of most malfunctions during scheduled maintenance events

MAINTENANCE SCHEDULING

The normal flow of events and requirements the SERT will use in developing an integrated maintenance schedule is illustrated in figure 4-9. This figure shows maintenance management responsibilities and the sequence of events that flows from the departmental master and work center PMS record books (containing the Maintenance Index Pages [MIP]), through the scheduling tools (Cycle, Quarterly, and Weekly Schedules), to test actions, unscheduled (corrective) maintenance, and reporting. The figure does not show the variants and constraints the SERT must consider in the quarterly, weekly, and daily scheduling due to the shipboard environment. These considerations were discussed earlier in this chapter in the description of SERT.

Maintenance Index Page (MIP)

The MIP contains a brief description of the requirements on the maintenance requirement card for each item of equipment, including the periodicity code, the manhours involved, the minimum required skill level, and (if applicable) the related maintenance requirements. The MIPs for all equipments in a department are contained in the department master PMS record. The department master PMS record is used by the department head to schedule maintenance on the PMS schedule forms. Each work center has a PMS record that contains the MIPs that apply to that work center.

Cycle Schedule

The Cycle Schedule is used by the combat system officer (CSO) to plan quarterly, monthly, and other requirements. It is a visual display of preventive maintenance requirements based on the ship's overhaul cycle.

Quarterly Schedule

The Quarterly Schedule, planned from the Cycle Schedule, is a visual display of the ship's employment schedule. This schedule is prepared by the CSO in cooperation with division officers, maintenance group supervisors, the system testing officer, and SERT members, and shows the current status of preventive maintenance for each group. The Quarterly Schedule assigns specific requirements in conjunction with the ship's operational schedule.

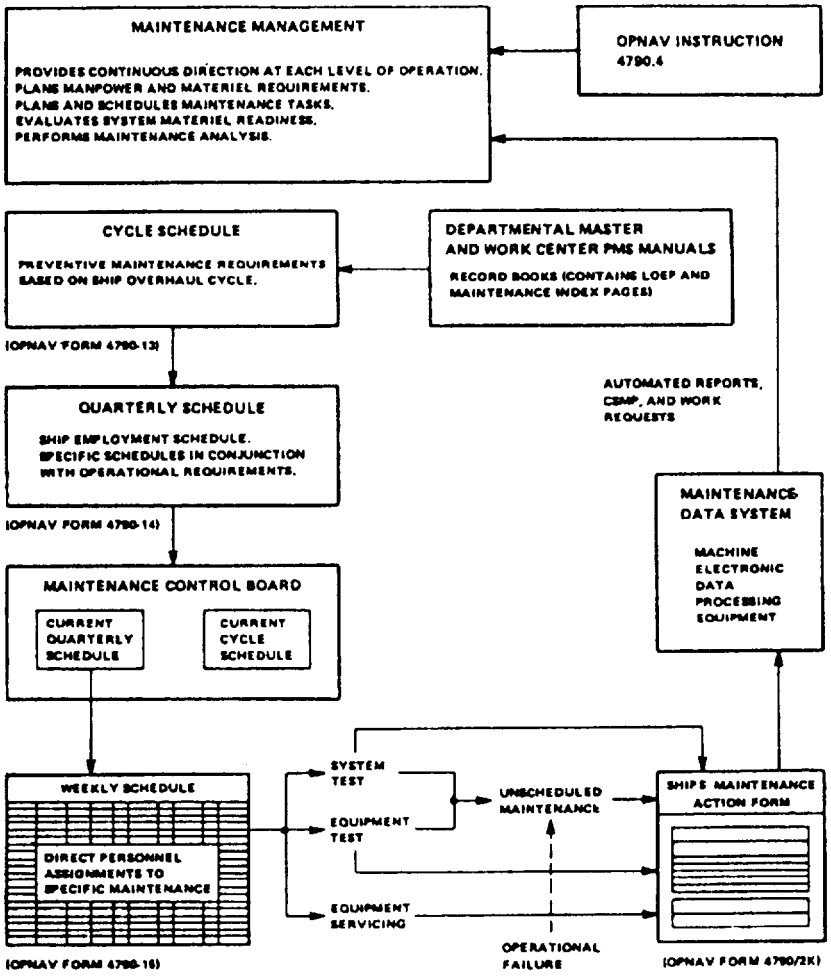


Figure 4-9.–Planned maintenance system.

Maintenance Control Board

The maintenance control board contains the Cycle Schedule and the current and subsequent Quarterly Schedules. The board summarizes the status of current and planned combat system preventive maintenance.

Weekly Schedule

The Weekly Schedule is a visual display that is posted in the working area of each maintenance group. The maintenance group supervisor uses the Weekly Schedule to assign specific personnel to perform maintenance on specific equipment. Assignments include system and equipment tests and servicing procedures.

MAINTENANCE DATA SYSTEM

The Maintenance Data System (MDS) provides a means of recording maintenance actions, processing the recorded data to define important facts about maintenance and equipment, and retrieving information for analysis. Significant data identified by the system include the reason the malfunction occurred, how it was discovered, manhours used in correcting the problem, exact equipment affected, delays in repair and reasons for delays, and types of maintenance personnel required.

Recording

Maintenance personnel document certain shipboard maintenance actions and corrective maintenance on specific categories of equipment at the time they actually perform or defer the maintenance action. Information is recorded and put into the MDS using OPNAV Form 4790/2K, Ship's Maintenance Action.

The MDS data processing facilities collect, store, and analyze maintenance information inputs into the system to yield data concerning equipment maintainability and reliability, manhours usage, equipment alteration status, material usage and costs, and fleet materiel condition. Various automated reports are produced periodically for the ship, repair activities, unit commanders, and type commanders. These automated reports include a current ship's maintenance project file, work requests, and preinspection and survey deficiency listings.

INTEGRATED MAINTENANCE

Combat system maintenance is based on a comprehensive schedule of tests performed at three mutually supporting levels: (1) **combat system,** (2) **subsystem,** and (3) **equipment.** These integrated tests are designed to test all combat system functions, parameters, and characteristics periodically against specified tolerances. Successful equipment performance during the tests usually indicates that the system is combat ready.

Integrated maintenance requirements are developed through engineering analysis, based on a study of all factors that significantly affect maintenance. The analysis defines system and equipment functions, and sets tolerances (in terms of system parameters) that allow operators and technicians to determine whether or not the system is operating properly.

Integrated maintenance procedures provide minimum preventive maintenance coverage of the combat system and are designed to test specific functions under specific conditions. Sometimes equipment operators and technicians may not understand the purposes of the tests. However, they must still follow the procedural sequence explicitly. Improvising or shortcutting procedural sequences often leads to incorrect troubleshooting or masking of actual faults.

The integrated maintenance concept follows PMS principles and is the most effective way to achieve PMS goals. Adhering to this concept enables the SERT to manage the combat system maintenance effort and achieve an optimum level of readiness with the most effective use of available manpower.

COMBAT SYSTEM TESTING

Combat system testing is conducted at three levels: (1) combat system, (2) subsystem, and (3) equipment. Integrated maintenance tests must be scheduled to reduce redundancy wherever possible. The three levels of testing are described in the following paragraphs.

SYSTEM TESTING

Combat system testing exercises the entire combat system. It is the highest level of testing that can be done on board ship. Combat system tests are usually automated and monitored in the combat direction system (CDS) subsystem.

While these tests provide an overview of system performance, they usually do not test the full capability of the combat system. It is impractical, from an instrumentation and manpower standpoint, to test all of the functional requirements at the system level. Therefore, confidence in operability or materiel readiness is mainly dependent on integrated testing at the subsystem or equipment level.

System-level tests provide a verification of the alignment between sensors; on-line, real-time monitoring of combat system interfaces; and an overall test of the 3-D search radar and its interface with the CDS. These tests are described in the synoptic test descriptions in the CSTOM.

SUBSYSTEM TESTING

Subsystem testing exercises two or more pieces of equipment functionally contained within the same subsystem. The intent of subsystem testing is to test **intra**subsystem (within the subsystem); but with the need for integrated testing, some functions are tested **inter**subsystem (outside of the subsystem).

The **subsystem operability/readiness test** is the keystone of integrated subsystem testing. The subsystem operability/readiness test consists of a rigidly controlled sequence of steps designed to test all critical functions during a primary mode of operation. The subsystem operability/readiness test and a supporting family of system tests use the concept of end-point testing in which functions are stimulated at their terminal point, thereby verifying all operations within the function. Subsystem tests are functionally grouped and mode-oriented so related functions may be tested using the same setup, procedures, and stimuli.

EQUIPMENT-LEVEL TESTING

Equipment-level testing generally concerns power levels, frequencies, servos, special features, and output functions. The equipment PMS may require special external stimulating equipment and special- or general-purpose test equipment for test measurements. These test measurements are often time-consuming and difficult to complete, but are always checked by the SERT in their effort to ensure optimum readiness.

FAULT ISOLATION

The goal of fault isolation is to determine systematically the part or condition responsible for a fault or degraded operation during testing or tactical operation. The process often involves impact evaluation. Impact evaluation requires considering whether to (1) ignore the problem for the time being; (2) switch to alternate equipment; or (3) perform corrective maintenance right away. Impact evaluation information is provided in the CSTOM.

The CSTOM provides fault isolation procedures both for faults that were detected during operations and for faults that were known before the operations. After a fault has been isolated to a specific unit or interface, corrective action in the form of repair, replacement, or alignment must be taken. In the integrated maintenance concept, alignment is considered as corrective maintenance only and, like other corrective action, should be performed only when a fault is indicated.

VERIFICATION

Fault isolation leads to corrective maintenance. The corrective maintenance performed may or may not bring the system back to an operable condition. There may have been more than one fault contributing to the out-of-tolerance condition that started the fault isolation process. The possibility of faulty replacement parts and incorrect adjustment or alignment also exists. Corrective maintenance may not have solved the problem, and may even have added to it. Therefore, each corrective action must be followed by verification. Verification normally is done by re-creating the test environment and rechallenging the function. Where alignments are concerned, the verification process is complicated by a requirement that the effect of the maintenance upon other elements of the combat system be determined.

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